

The Diagnostic Accuracy of Bedside Ocular Ultrasonography for the Diagnosis of Retinal Detachment: A Systematic Review and Meta-analysis

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The diagnostic accuracy of emergency department (ED) ocular ultrasonography may be sufficient for diagnosing retinal detachment. We systematically reviewed the literature to determine the diagnostic accuracy of ED ocular ultrasonography for the diagnosis of retinal detachment. This review conformed to the recommendations from the Meta-analysis of Observational Studies in Epidemiology statement. An experienced medical librarian searched the following databases from their inception, without language restrictions: Ovid MEDLINE, PubMed, EMBASE, the Cochrane Library, Emergency Medical Abstracts, and Google Scholar. Content experts were contacted and bibliographies of relevant studies were reviewed to identify additional references. Evidence quality was independently assessed by 2 investigators using the revised Quality Assessment Tool for Diagnostic Accuracy Studies (QUADAS-2). Discrepancies were resolved by consensus or adjudication by a third reviewer. Diagnostic test characteristics were summarized and reported with 95% confidence intervals. Of 7,771 unique citations identified, 78 were selected for full-text review, resulting in 4 trials assessed for quality. Agreement between authors' QUADAS-2 scoring was good ($\kappa=0.63$). Three trials were deemed to have a low risk of bias. They enrolled ED-based patients (N=201) and evaluated clinician-performed bedside ocular ultrasonography, using either a 7.5- or 10-MHz linear-array probe. Two trials included patients who had retinal detachment from trauma. The prevalence of retinal detachment ranged from 15% to 38%. Sensitivity and specificity ranged from 97% to 100% and 83% to 100%, respectively. The results of the bedside ocular ultrasonography were compared with the reference standard of an ophthalmologic evaluation; one trial also included orbital computed tomography findings suggestive of retinal detachment. Bedside ocular ultrasonography has a high degree of accuracy in identifying retinal detachment, according to 3 small prospective investigations. Larger prospective validation of these findings would be valuable. [Ann Emerg Med. 2015;65:199-203.]

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INTRODUCTION

Ocular complaints represent between 2% and 3% of emergency department (ED) visits.¹ Many of these visits are for acute visual impairment, with a differential diagnosis that includes a number of time-sensitive conditions requiring rapid and accurate assessment.¹ Retinal detachment is one such condition and has a prevalence as high as 3.6% in this cohort.² Classically, patients describe a sudden, painless, monocular visual impairment with the sensation of looking through a curtain, accompanied by flashes and floaters. Evaluation of patients presumed to have a retinal detachment requires examination of the posterior segment of the eye. Unfortunately, appropriate evaluation of the posterior segment often necessitates specialized equipment and expertise not readily available in most EDs.

Sonographic evaluation of the eye offers an alternative diagnostic modality that can be used by ED clinicians. Ophthalmologists have used diagnostic ultrasonography since the 1940s and began using it specifically for retinal detachment as early as the 1960s.^{3,4} Although the emergence of ED ultrasonography

has resulted in a number of clinical trials, there is no consensus on its accuracy for the diagnosis of retinal detachment.⁵⁻⁸ We therefore systematically reviewed the available literature to determine the diagnostic performance of bedside ultrasonography in the evaluation of retinal detachment.

METHODS

This systematic review conformed to the recommendations from the Meta-analysis of Observational Studies in Epidemiology statement.⁹

DATA SOURCES AND SEARCHES

A comprehensive search of the literature was performed by an experienced medical librarian (T.W.E.) using the following databases: Ovid MEDLINE, PubMed (for non-MEDLINE records), EMBASE, the Cochrane Library, Emergency Medical Abstracts, and Google Scholar. Searches were conducted from August 17 to 21, 2012, and all databases were searched from

their inception. Additionally, content experts were contacted and bibliographies of relevant studies were reviewed to identify additional references.

The search strategies for each database are reported in Appendix E1 (available online at <http://www.annemergmed.com>). Database-specific subject headings and key words for retinal detachment, tears, or perforations were combined with subject headings, subheadings, and key words for diagnostic findings that included, but were not limited to, the patient history, physical examination, laboratory testing, and diagnostic imaging. Animal studies and single case reports were excluded. No language restrictions were applied.

QUALITY ASSESSMENT

Studies were included if they prospectively evaluated the diagnostic performance of bedside ultrasonography for patients with acute ocular complaints worrisome for retinal detachment compared with a criterion standard. Retrospective investigations, case reports, and case series were excluded. Evidence quality was independently assessed by 2 investigators (H.J.M., J.M.K.) using the revised Quality Assessment Tool for Diagnostic Accuracy Studies.¹⁰ Briefly, this tool assesses diagnostic trials in 4 domains: patient selection, the index test, reference standard, and flow and timing. Each domain is scored as having a high, a low, or an unclear risk of bias. Discrepancies were resolved by consensus or adjudication by a third reviewer (R.A.S.). An unweighted κ statistic was calculated to assess agreement between raters. Trials deemed to be at a high risk of bias were excluded from analysis.

DATA ANALYSIS

Two authors (H.J.M., J.M.K.) independently extracted data from included trials. Extracted elements included the study setting, basic patient demographic information, description of the criterion standard, and diagnostic test properties. Statistical analyses were performed with Review Manager (version 5.0) for forest plot. Because of the small number of studies, variation of ultrasonographic operator experience, and differences in definitions of a positive test result, estimates of sensitivity and specificity, as well as likelihood ratios, were not pooled to preserve the integrity of the individual data. Individual and summary receiver operator curves were constructed, with corresponding areas under the curve calculated. Sensitivity and specificity were calculated with 95% confidence intervals (CIs).

RESULTS

The search identified 7,771 unique citations, 5,536 from MEDLINE, 2,164 from EMBASE, and 71 from the Cochrane Library. Seventy-eight were selected for full-text review. Four met inclusion criteria and were subsequently assessed for quality (Figure 1). Agreement between authors' revised Quality Assessment Tool for Diagnostic Accuracy Studies scoring was good ($\kappa=0.63$).

Three trials were deemed to have low risk of bias and were included in the meta-analysis (Figure 2). All studies were

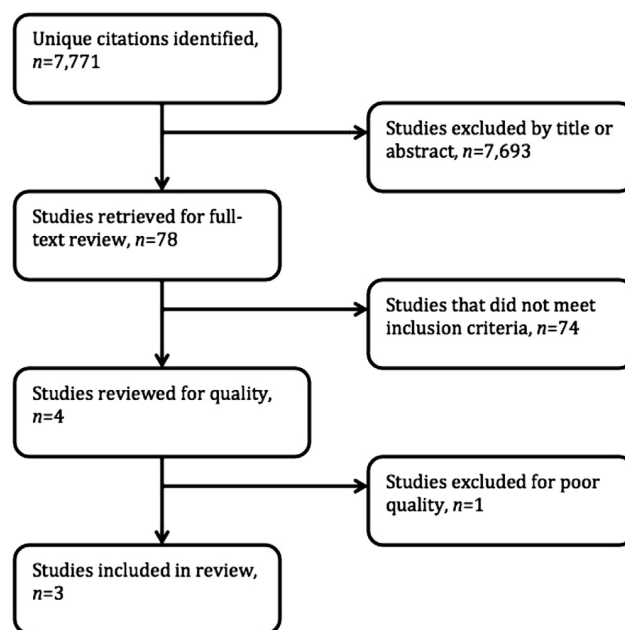


Figure 1. Flowchart of study identification and inclusion.

prospective observational trials of ED patients evaluated with clinician-performed bedside ocular ultrasonography, using either a 7.5- or 10-MHz linear array probe. Results of the included studies are summarized in Figure 3 and the Table.

In 2002, Blaivas et al⁸ enrolled 61 subjects with ocular complaints or trauma at a suburban academic ED. Emergency medicine attending physicians and residents received a 1-hour lecture and 1 hour of hands-on instruction before participating in the study. Reference standard testing was defined as either official orbital computed tomography findings or masked ophthalmologic evaluation. The prevalence of retinal detachment was 15%. The sensitivity and specificity were 1.00 (95% CI, 0.66 to 1.00) and 1.00 (95% CI, 0.93 to 1.00), respectively.

In 2011, Shinar et al⁶ enrolled 92 subjects in a large urban academic ED, with complaints concerning for retinal detachment. All but 4 instances of ocular ultrasonography were performed by emergency medicine residents who had received a 30-minute ocular ultrasonographic lecture. One attending physician and 3 physician assistants contributed 1 case each. The reference standard was ophthalmologic evaluation not blinded to the ED ocular ultrasonographic result. The prevalence of retinal detachment was 32%. Sensitivity and specificity were 0.97 (95% CI, 0.82 to 1.00) and 0.92 (95% CI, 0.82 to 0.97), respectively.

In 2010, Yoonessi et al⁷ enrolled 48 subjects at an urban academic ED who presented with acute (<48 hours' duration) vision change and were evaluated by an ophthalmologist within 12 hours. Emergency medicine attending physicians and residents who received a 20-minute ocular ultrasonographic lecture performed the index test. The reference standard was masked ophthalmologic evaluation. The prevalence of retinal detachment was 38%. Sensitivity and specificity were 1.00 (95% CI, 0.81 to 1.00) and 0.83 (95% CI, 0.65 to 0.94), respectively.

QUADAS-2 QUALITY ASSESSMENT

Study	RISK OF BIAS				APPLICABILITY CONCERNS		
	PATIENT SELECTION	INDEX TEST	REFERENCE STANDARD	FLOW AND TIMING	PATIENT SELECTION	INDEX TEST	REFERENCE STANDARD
Blaivas	LR	LR	LR	LR	LR	LR	LR
Yoonessi	LR	LR	LR	LR	LR	LR	LR
Shinar	?	LR	?	?	?	LR	LR

LR = Low Risk HR= High Risk ? = Unclear Risk

Figure 2. Quality assessment of included studies.

Receiver operating characteristic curves yielded excellent areas under the curve, ranging from 0.943 to 1.00. The summary area under the curve was 0.957.

LIMITATIONS

The findings of this systematic review should be tempered by its limitations. The overall sample size of included trials was small. We analyzed 3 studies performed in the ED setting that enrolled 201 eyes.^{5,6,7} Although our search parameters did not specifically exclude trauma, 2 trials studied patients who experienced a traumatic event.^{5,7} This may, in fact, improve the external validity of our findings because it supports the use of ultrasonography in a larger undifferentiated population. One trial used sonographers who were all fellowship trained and highly experienced, which may have positively skewed the test’s performance characteristics.⁵ However, the results of the other included trials, in which the level of expertise was variable, were similar.^{6,7} In 2 studies, there was insufficient information to exclude elements of referral or spectrum

bias.^{6,7} If present, this could have led to an overestimation of the sensitivity and specificity of the test.

In any diagnostic trial, variability in the test’s performance can significantly modify its diagnostic test characteristics. The same is true for ocular ultrasonography. Posterior chamber pathology identified in this meta-analysis included retinal detachment, vitreous hemorrhage, and vitreous detachment.⁵⁻⁷ These conditions are not always mutually exclusive. Standard views include axial and sagittal orientations. In only 1 of the studies did the sonographer ask the patient to look left and right to evaluate for retinal detachment versus vitreous hemorrhage or vitreous detachment.⁶ This technique can help differentiate these 3 conditions. Retinal detachment appears as a sharply defined, highly reflective linear membrane that is anchored to the optic disc. Because the retina is firmly attached to the optic disc, a retinal detachment may have a funnel-shaped appearance. The retina may appear to wave serpiginously with eye movements. Vitreous hemorrhage has a variable echogenicity, depending on its acuity, and although the echoes may move with eye

Study	N	TP	FP	FN	TN	LR +	LR -	Sensitivity [95% CI]	Specificity [95%, CI]
Blaivas, et al ⁵	61	9	0	0	52	-	0	1.00 [0.66,1.00]	1.00 [0.93, 1.00]
Yoonessi, et al ⁷	48	18	5	0	25	5.88	0	1.00 [0.81, 1.00]	0.83 [0.65, 0.94]
Shinar, et al ⁶	92	28	5	1	58	12.13	0.03	0.97 [0.82, 1.00]	0.92 [0.82, 0.97]

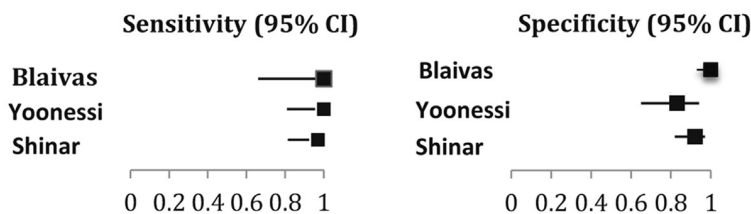


Figure 3. Summary of results of included studies. TP, True positive; FP, false positive; FN, false negative; TN, true negative.

Table. Summary of Study Methodology.

Study	Characteristics	Index Test and Ultrasonographic Operators	Reference Standard
Blaivas ⁵	Enrollment: 61 of 134 patients, unclear whether consecutive Inclusion criteria: acute vision change (<48 h) or trauma and also had a confirmatory test result Exclusion criteria: binocular diplopia, ultrasonography interfered with care Setting: suburban academic ED	Bedside ultrasonography: Phillips Image Point HX,* 10-MHz linear transducer; transverse and longitudinal views Positive test definition: unclear Masked sonologist: unclear Operators: 3 attending physicians with previous ocular ultrasonographic experience; 5 residents with 1 h lecture and 1 h hands-on training	Computed tomography or masked ophthalmologist evaluation. All RDs were confirmed by ophthalmology.
Yoonessi et al ⁷	Enrollment: convenience sample of 48 patients of 312 with acute vision change (<48 h) with ED ultrasonography performed before and within 12 h of ophthalmology evaluation Exclusion criteria: non-English speakers, unable to consent, known diagnosis Setting: urban academic ED	Bedside ultrasonography: Aloka SSD 1400, [†] 7.5-MHz linear transducer or Ultrasonix CEP, [‡] 7.5-MHz linear transducer; transverse and longitudinal views Positive test definition: abnormal lifting of retina or a retinal flap Masked sonologist: yes Operators: 2 experienced attending physicians, 13 residents with a 20-min lecture and 1 observed examination	Final ophthalmology diagnosis masked to ED ultrasonography findings and performed within 12 h of ED presentation
Shinar et al ⁶	Enrollment: convenience sample of 92 eyes and emergency physician concerned for RD Inclusion criteria: concern for RD, patients received ED ultrasonographic and ophthalmologic evaluation Exclusion criteria: not stated Setting: urban academic ED	Bedside ultrasonography: Aloka SSD 1400, [†] 10-MHz linear transducer; views not stated Positive test definition: taut linear opacity within the vitreous that moves with eye movement Masked sonologist: no Operators: 27 residents, 1 attending physician, 3 physician assistants; all had a 30-min lecture	Final ophthalmology diagnosis unmasked to ED ultrasonographic findings

RD, Retinal detachment.

*Philips Medical Systems, Palo Alto, CA.

[†]Aloka Inc, Wallingford, CT.

[‡]Ultrasonix, Richmond, British Columbia, Canada.

movements, they are less well defined and appear to move side to side. Posterior vitreous detachments occur as a result of separation of the posterior part of the vitreous from the retina, whose appearance depends on the extent of the detachment. In this case, the hyaloid membrane that separates from the retina is not likely to move with eye movements. Taken together, these observations suggest that imaging technique plays a role in differentiating retinal detachment from other posterior chamber abnormalities. This is supported by the results of Yoonessi et al,⁷ who found that all patients who were misidentified as having retinal detachments in fact had vitreous hemorrhages, 80% of whom also had concomitant vitreous detachments. Despite this potential limitation, diagnostic test characteristics were consistent across all 3 analyzed trials.⁵⁻⁷ This consistency fosters support of the findings presented in this systematic review.

DISCUSSION

Traditionally, the evaluation of the posterior eye for retinal detachment requires a dilated direct and indirect fundoscopic examination. In a busy ED or acute care setting, the equipment and expertise to perform an appropriate examination are not often available. Bedside ocular ultrasonography, however, can provide a reliable alternative method of examining the posterior segment of the eye. We performed a systematic review of the literature to determine whether this practitioner-performed test accurately detects retinal detachment in the acute care setting.

Our exhaustive search found that the use of ocular ultrasonography was described as early as the 1940s.³ Despite a large number of potentially relevant titles, only 3 trials with a low risk of bias met our inclusion criteria. All 3 trials were performed in an ED setting.⁶⁻⁸

The most impressive diagnostic results came from Blaivas et al,⁸ who diagnosed retinal detachments with 100% sensitivity and specificity. This may be explained by the experience of the investigators because most had extensive ED ultrasonographic training, including fellowships. Although the use of ocular ultrasonography is not difficult, these results may not be reproducible in a more heterogeneous population of emergency physicians.

The trials by Yoonessi et al⁷ and Shinar et al⁶ also reported high sensitivities and specificities for the detection of retinal detachment (Figure 3). Unlike the study by Blaivas et al,⁸ these trials used academic ED practitioners and residents who had short training sessions on ocular ultrasonography. Despite the relative lack of expertise, their findings were consistent with those found in the trial by Blaivas et al.⁸ The emergency physicians in these 2 trials are more representative of a broad cross section of providers without fellowship training in emergency ultrasonography.

Although the overall risk of retinal detachment is low (estimated of prevalence of 3.6% of eye complaints presenting to the ED),² the prevalence of retinal detachment in 2 of the included trials ranged from 32% to 38%.^{6,7} Although this discrepancy may limit the utility of reporting predictive values, it is unlikely that the reported sensitivities and specificities would be significantly modified.

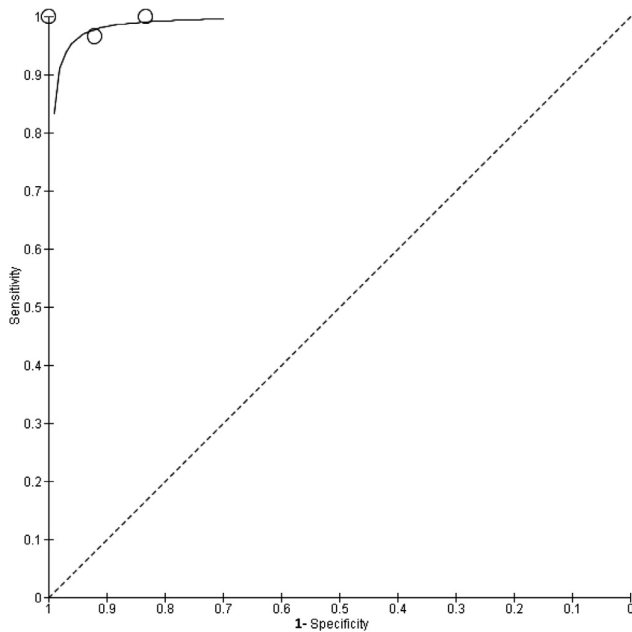


Figure 4. Summary receiver operating characteristic curve. Summary area under the curve was 0.957.

As expected, according to the reported test characteristics, the summary area under the curve (0.97) was excellent (Figure 4). According to these data, ED ocular ultrasonography can discriminate between patients with and without retinal detachment with a high degree of accuracy.

In a busy ED, performing a complete, dilated fundoscopic examination may be impractical and ophthalmology coverage may not be available. According to available data, ED bedside ocular ultrasonography offers an accurate alternative to assist in the diagnosis of acute vision change. This diagnostic test provides rapid assessment of the posterior elements of the eye, with the ability to identify posterior eye pathology or rule out retinal detachment with a high degree of discrimination. Although it is likely that this modality can assist in the detection of other posterior segment pathologies, the clinical question answered by this review is focused solely on retinal detachment. As bedside ultrasonography use and practitioner proficiency continue to increase, this imaging modality has the potential to improve detection of retinal detachment, decrease time to definitive care, and provide more robust information for ophthalmologic consultation. Furthermore, this technique can be learned quickly and is noninvasive, safe, and inexpensive because most EDs are already equipped with ultrasonographic machines.^{6,7,11,12}

CONCLUSION

Bedside ocular ultrasonography can be used to diagnose retinal detachment with a high degree of accuracy. The fundamental utility of ultrasonography and its speed, noninvasive nature, and cost-effectiveness suggest that it is an ideal tool for busy emergency medicine clinicians. Additional prospective

observational trials with larger sample sizes should be performed to validate these findings.

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APPENDIX E1.

Detailed search strategies.

MEDLINE (Ovid):

- 1 exp Retinal Detachment/bl, cf, di, ra, ri, us [Blood, Cerebrospinal Fluid, Diagnosis, Radiography, Radionuclide Imaging, Ultrasonography]
- 2 exp Retinal Perforations/bl, di, ra, us [Blood, Diagnosis, Radiography, Ultrasonography]
- 3 exp Retinal Detachment/
- 4 exp Retinal Perforations/
- 5 exp Medical History Taking/
- 6 exp Physical Examination/
- 7 exp Vision Disorders/
- 8 (photopsia* or flash* or floater*).mp.
- 9 exp Ophthalmoscopy/
- 10 exp Vision Tests/
- 11 (fundoscop* or funduscop* or ophthalmoscop* or slitlamp* or slit lamp*).mp.
- 12 exp Ultrasonography/
- 13 exp Biological Markers/
- 14 exp "Sensitivity and Specificity"/
- 15 exp Emergency Medical Services/
- 16 (or/3-4) and (or/5-15)
- 17 1 or 2 or 16
- 18 exp Animals/ not exp Humans/
- 19 exp Case Reports/ not (exp Review/ or review.ti.)
- 20 17 not (18 or 19)

PubMed (PubMed.gov):

- #1 "retinal detachment" OR "detached retina"
- #2 retina* [ti] AND (detach* [ti] OR tear* [ti] OR break* [ti] OR hole* [ti] OR perforat* [ti] OR dialys* [ti])
- #3 diagnose* OR diagnosis OR diagnostic* OR histor* OR physical OR exam* OR photopsia* OR flash* OR floater* OR "visual acuity" OR "visual field" OR "visual fields" OR fundoscop* OR funduscop* OR ophthalmoscop* OR slitlamp OR "slit lamp" OR ultrasound* OR ultrasonogra* OR sonogra* OR marker* OR sensitiv* OR specific* OR emergenc*
- #4 (#1 OR #2) AND #3
- #5 #4 NOT medline [sb]

Embase (Embase.com):

- #1 'retina detachment'/exp/dm_di
- #2 'retina tear'/exp/dm_di
- #3 'retina detachment'/exp
- #4 'retina tear'/exp
- #5 'medical history'/exp
- #6 'physical examination'/exp
- #7 'vitreous floaters'/exp
- #8 'visual disorder'/exp
- #9 photopsia* OR flash* OR floater*
- #10 'ophthalmoscopy'/exp
- #11 'scanning laser ophthalmoscopy'/exp
- #12 'vision'/exp
- #13 fundoscop* OR funduscop* OR ophthalmoscop* OR slitlamp* OR slit NEXT/1 lamp*
- #14 'visual system examination'/exp
- #15 'ultrasound'/exp
- #16 'echography'/exp
- #17 'laboratory diagnosis'/exp
- #18 'biological marker'/exp
- #19 'sensitivity and specificity'/exp
- #20 'evidence based medicine'/exp
- #21 'emergency medicine'/exp
- #22 'emergency ward'/exp
- #23 (#3 OR #4) AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22)
- #24 #1 OR #2 OR #23
- #25 'animal'/exp NOT 'human'/exp
- #26 'case report'/exp NOT ('review'/exp OR review.ti)
- #27 #24 NOT (#25 OR #26)

Cochrane Library (Wiley):

- ("retinal detachment":ti,ab,kw OR "detached retina":ti,ab,kw) AND (diagnos*:ti,ab,kw OR histor*:ti,ab,kw OR physical:ti,ab,kw OR exam*:ti,ab,kw OR photopsia*:ti,ab,kw OR flash*:ti,ab,kw OR floater*:ti,ab,kw OR "visual acuity":ti,ab,kw OR "visual field":ti,ab,kw OR "visual fields":ti,ab,kw OR fundoscop*:ti,ab,kw OR funduscop*:ti,ab,kw OR ophthalmoscop*:ti,ab,kw OR slitlamp:ti,ab,kw OR "slit lamp":ti,ab,kw OR ultraso*:ti,ab,kw OR sonogra*:ti,ab,kw OR marker*:ti,ab,kw OR sensitiv*:ti,ab,kw OR specific*:ti,ab,kw OR emergenc*:ti,ab,kw)